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IMPACTS OF LOW LAKE ERIE WATER LEVELS ON MARINA ACTIVITY AND THE REGIONAL ECONOMY OF NORTHERN OHIO

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

IMPACTS OF LOW LAKE ERIE WATER LEVELS ON MARINA ACTIVITY AND THE REGIONAL ECONOMY OF NORTHERN OHIO

Introduction

The marina industry of Lake Erie's western basin region has grown considerably in recent years. This growth is attributed in part to the increasing demands of sport anglers who are drawn to the region by the number and variety of fish species found there. Policies of the Ohio Department of Natural Resources (ODNR) have also encouraged sport fishing in the area. At the same time, the greatest expansion of the marina industry has occurred during a period of relatively high average water levels on the Lake.

The objectives of this study were threefold. the first was to gain an understanding of the extent and characteristics of the rapidly-changing marina industry in the counties bordering Ohio's western basin. To accomplish this objective, information concerning the number and location of marinas and their hoists, ramps, docks and rack spaces was collected. The second objective of the study was to ascertain if and how declining Lake Erie water levels would affect the marina industry and, in turn, sport fishing activity in the region. This was accomplished by determining the proportion of marinas and public launch ramps that would be rendered inoperable should Lake Erie water levels drop below those experienced in recent years. Finally, through the use of a 43-sector input-output model and previous studies that estimated the economic value associated with sport fishing on Lake Erie by sport anglers, the impacts of the resulting decline in marina-related activity were evaluated.

The Study Region

The study region consisted of four counties in northwestern Ohio bordering on that section of Lake Erie commonly known as the western basin (Figure 1): Lucas, Ottawa, Sandusky and Erie. The study focused on this area since most of the fish caught by sport anglers in the Ohio waters of Lake Erie are taken in the western basin (Table 1). Marinas located on the lakefront as well as those found along some of the major rivers in the area were included in this study since they would all be affected if the Lake water level declined.

Lake Erie Water Levels

Water depths on the Great Lakes are expressed in terms of "feet at low water datum." Low water datum is defined as "an artificial fixed water surface used as a basis for measurement" (Great Lakes, 1975). Because water levels on the Lakes are changing constantly, low water datum serves as a standard reference point to which all water level variations are compared. The Lake Erie low water datum standard is 568.6 feet above sea level.

Lake Erie water levels fluctuate seasonally due to a number of natural processes (Figure 2). Generally the Lake reaches its peak volume during the summer and declines to its low point in the winter months. Among the factors that account for these seasonal variations are precipitation, runoff, freezing, snow and ice melt and evaporation. Minor contributions have been attributed to ground water flows and crustal movements (Great Lakes, 1975).

Table 1. Geographical Distribution of Ohio Sport Harvest in Numbers of Fish by Species, 1981

Fish Species	Western Basin	Central Basin	Total
	numbers of fish (percent)		
Yellow Perch	10,465,473 (93)	834,647 (7)	11,300,130 (100)
Walleye	2,878,228 (97)	84,675 (3)	2,962,903 (100)
White Bass	524,277 (35)	974,582 (65)	1,498,859 (100)
Smallmouth Bass	18,550 (42)	25,313 (58)	43,863 (100)
Freshwater Drum	245,881 (59)	172,846 (41)	418,727 (100)
Channel Catfish	120,265 (93)	9,217 (7)	129,482 (100)
Total	14,252,674 (87)	2,101,290 (13)	16,353,964 (100)

Source: Status, 1982.

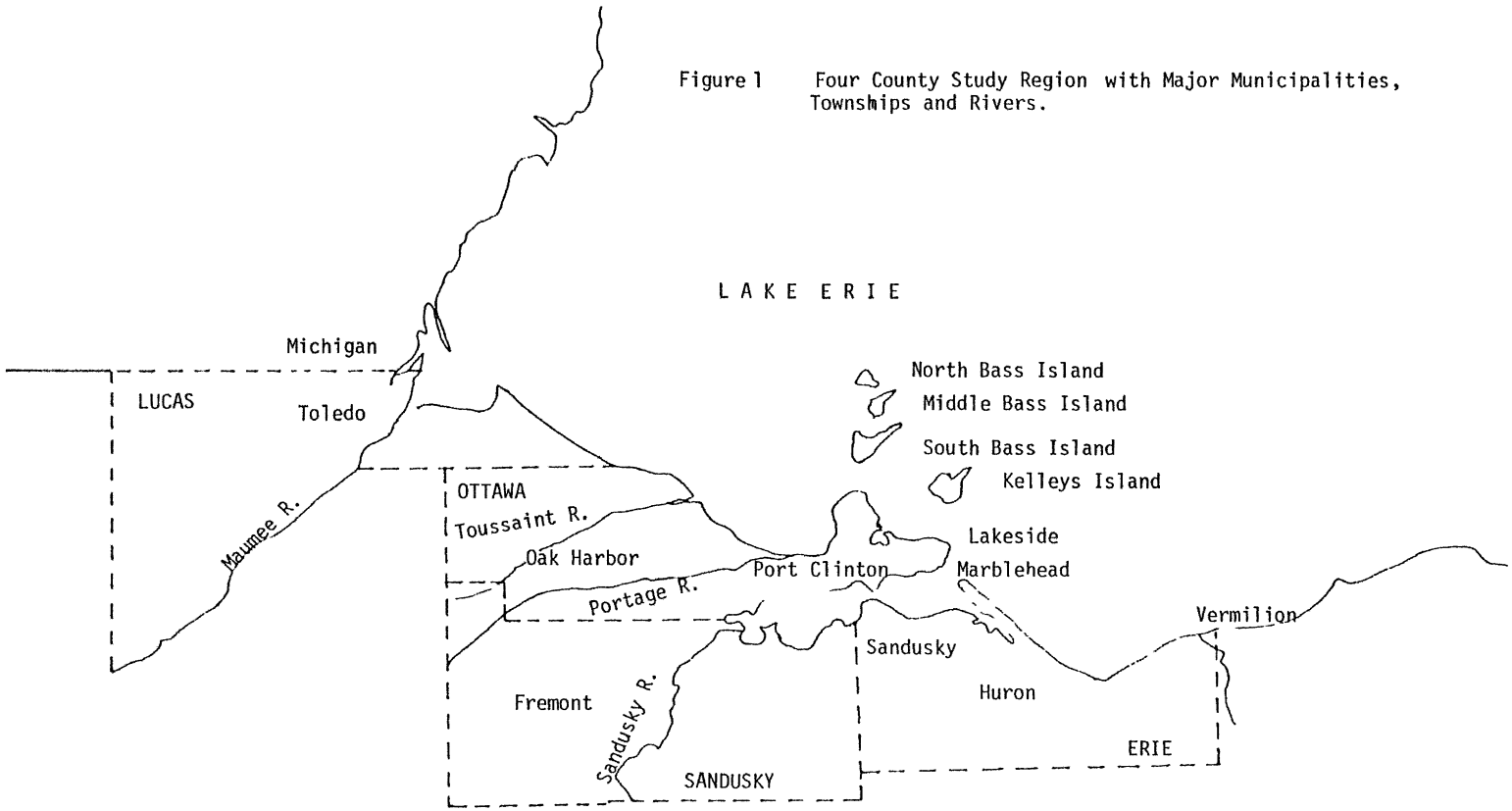
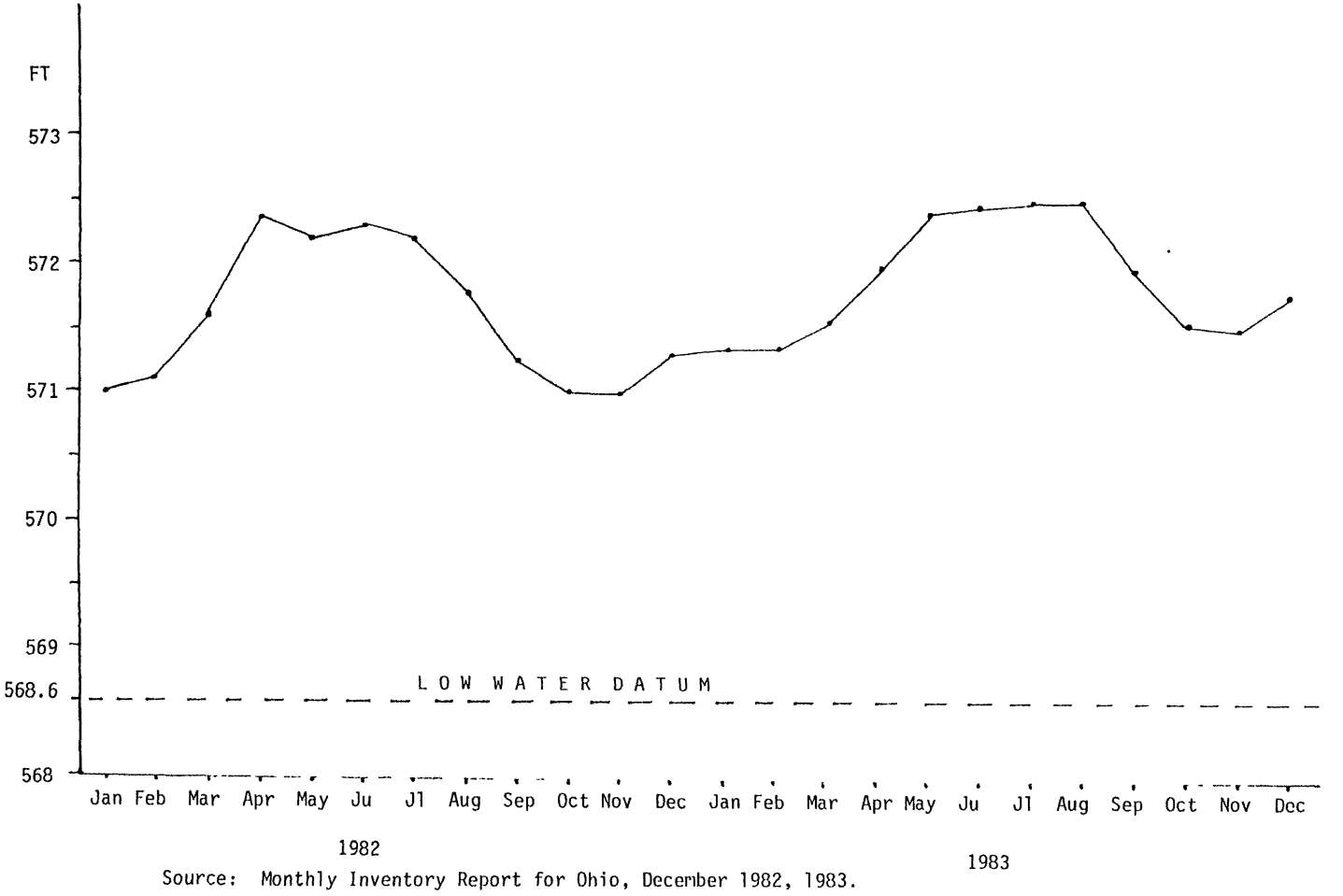


Figure 1 Four County Study Region with Major Municipalities, Townships and Rivers.

Figure 2. Monthly Average Lake Erie Water Surface Elevations at Cleveland, Ohio, 1982 and 1983.



Source: Monthly Inventory Report for Ohio, December 1982, 1983.

Precipitation falling over the Lake contributes directly to its water volume. Runoff carried by streams and rivers within the Lake's natural drainage basin also accounts for some of the variation. The main impact of precipitation is felt between May and December.

Snow and ice melt in the spring adds to Lake Erie's volume whereas evaporation, which peaks in the fall, has a negative affect. Since the waters of Lakes Superior, Michigan and Huron eventually feed into Lake Erie, variations in the amount of precipitation, runoff, snow and ice melt and evaporation at and around those sites play a role in determining Lake Erie water volume as well.

Diversions of water to and from the Lake for public use and industrial purposes also influence water levels as does regulation of water outflow from natural Lake outlets. However, the net total effect of such actions has been estimated to lower Lake Erie by less than two and one half inches (Great Lakes, 1975). Overall, most of the water level fluctuation occurring on Lake Erie is attributed to natural environmental influences.

Variations in Lake Erie water levels also occur from year to year, but attempts to demonstrate long-term cycles or patterns have not been successful. However, a graph of average June water levels plotted over time demonstrates an upward trend beginning in the early 1970s, a period coincident with the acceleration of marina construction in the area (Figure

3).[1] Contributing in part to this trend were increased amounts of precipitation that occurred in the natural Great Lakes drainage basin (U.S. Army, 1977).

Average June water levels are used as a reference point throughout this study. Boat angler hours for the 1981 fishing season are summarized in Table 2. The data indicate that although the season extends from May to October, the height of fishing activity occurs in June and July.

Data Sources

Numerous sources were consulted in an effort to compile a comprehensive list of marinas operating in the four-county study area. The Boating Facilities Inventory of 1979 was used as a starting point (Mischon, et al. 1979). This source listed marina names and addresses as well as the number of ramps, hoists and dock spaces associated with each facility. Thereafter, additions to or subtractions from this list were made after consulting other more current data sources.

The yellow pages of recent telephone directories of major municipalities and towns within the region under the heading "Marinas" were examined and cross-referenced with the Boating Facilities Inventories list. Eight local Chambers of Commerce were contacted by telephone and asked to provide the names and addresses of marinas currently in operation in their areas.

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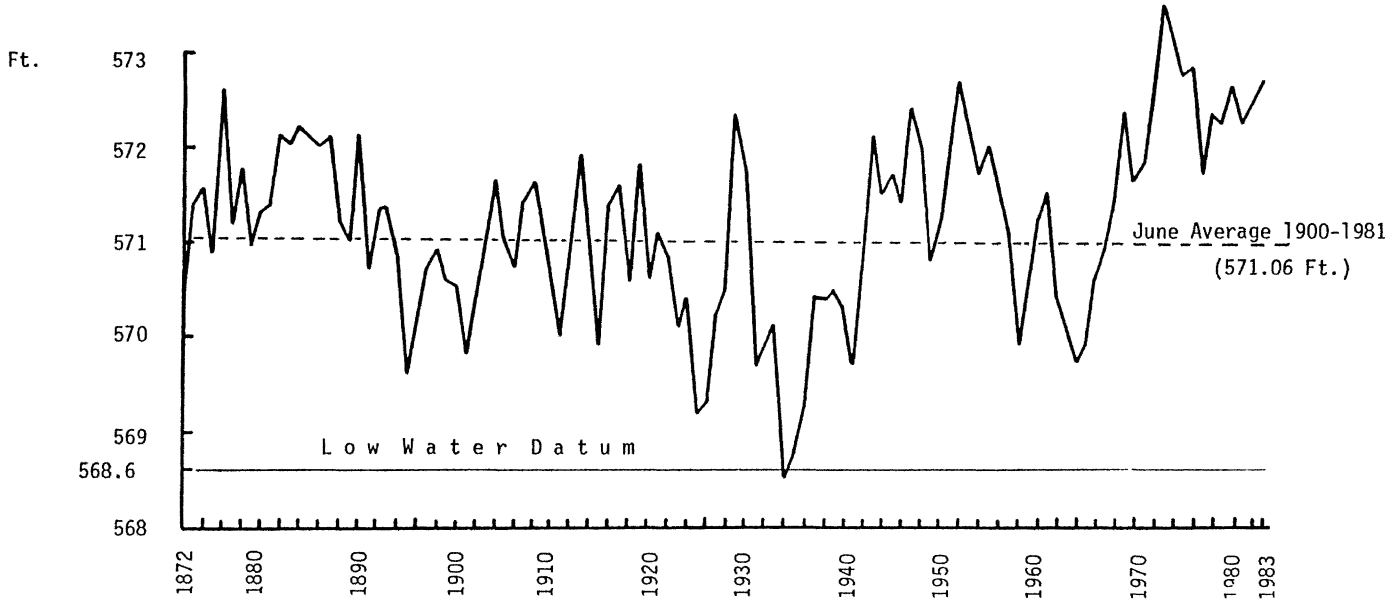
1 Water gauge stations on the Ohio portion of Lake Erie are located at Toledo, Marblehead, Cleveland and Fairport. Cleveland figures were used in the graph (Figure 3) because continuous long-term data were not available from the two stations located within the study region. However, the differences between average monthly water levels measured at these stations are usually only several hundreths of an inch, a variation of little consequence to this study.

Figure 3. Average June Lake Erie Water Surface Elevations at Cleveland, Ohio, 1872-1983.



Source: USDC -- NOAA, No date.

Table 2. Total Boat Angler Hours Spent in Lake Erie's Western Basin, May-October, 1981

Month	Boat Angler Hours
	number (percent)
May	630,432 (7)
June	2,738,473 (29)
July	3,102,566 (33)
August	1,528,482 (16)
September	1,004,447 (11)
October	329,614 (4)
Total	9,334,014 (100)

Source: Carl T. Baker, Personal Communication.

In the state of Ohio, county and municipal health departments are required by law to inspect marinas having seven or more docks (ODH, no date). All four county health departments and the Toledo Health Department were contacted and asked to send the most current lists of marinas within their jurisdictions. Three of the five lists contained information on the number of dock spaces available at the marinas. These figures were used instead of the ones provided in the Boating Facilities Inventory because the former are more current.

The marina list was continually cross-checked to avoid duplication. Careful attention was given to the marina addresses, not only because marinas eventually had to be located on maps but because a number of marinas were listed in various sources under different names. Where discrepancies existed, local Chambers of Commerce were telephoned and asked to verify the information.

To identify and locate public launch ramps in the region, directories published by the ODNR were consulted ($ODNR_a$, 1977, $ODNR_b$, no date). Marina ramp and hoist data were obtained from the Boating Facilities Inventory. In some cases, marina names were printed on maps indicating the presence of hoists and/or ramps as well. Water levels at marina and public ramp sites were determined by consulting detailed navigational maps of the Lake Erie coastline and river systems published by the National Oceanic and Atmospheric Administration (US-GL, Lake Erie-OH, US-GL, MI-OH).

Dry rack storage is a relatively new innovation for Lake Erie. It has proved to be a viable alternative for marina operators who find expansion of their waterfront facilities to be financially prohibitive or physically impossible. It has also been advantageous for boat owners wishing to avoid long lines at public launch ramps or to reduce hauling costs if water dock

space is unavailable. With rack storage, boats are stacked on frames which are often but not always housed in warehouse-like buildings. At the owner's request, the boat is removed from the rack, brought to the water's edge and lowered into it, all in a matter of minutes. Upon the owner's return, the boat is lifted out of the water and placed once again in its space on the rack.

To determine which marinas had rack storage facilities, a representative from the Lake Erie Marine Trades Association was contacted and asked to name marinas in the study region that operated such facilities. Those marina operators or managers were telephoned and asked to specify the number of dry rack spaces they maintained. To assure that all marinas in the area having rack storage were identified, the marina representatives were asked if they had knowledge of other facilities with rack storage space. Those so identified were added to the list and subsequently were surveyed by telephone.

Description of the Marina Industry

In total, 213 marinas were identified and located on the NOAA maps of the Lake Erie coastline and rivers of the study region. Four other marinas were identified but could not be located on the NOAA maps so they were dropped from the analysis. A comparison between the number of marinas found in the region in 1979 and in 1984 showed an increase of 23 percent (Table 3). Proportionally, there was an increase in the number of marinas in Lucas county and a small decline in Ottawa and Sandusky counties. However, Ottawa county has remained the center of marina activity in the western basin with over 60 percent of the facilities.

Table 3. Number of Marinas in the Study Region by County, 1979 and 1984

County	Marinas	
	1979[1]	1984
	number (percent)	
Ottawa	116 (67)	137 (64)
Erie	40 (23)	48 (23)
Lucas	12 (7)	23 (11)
Sandusky	5 (3)	5 (2)
Total	173 (100)	213 (100)

[1]It was assumed that Mischon, et. al. provided complete information.

Sources: Mischon, et. al., 1979, Oak Harbor Area Chamber of Commerce, Port Clinton Area Chamber of Commerce, Put-in-Bay Chamber of Commerce, Sandusky Bay Visitors and Convention Bureau, Toledo Area Chamber of Commerce, County and Toledo Health Department Marina lists.

Summary data for number of docks, marina ramps, hoists and public ramps by county are shown in Table 4. Two hundred and four marinas provided a total of 19,006 dock slips (information on dock numbers was not available for nine marinas). The mean number of docks was 93, the mode was 40 and the median was 58. By size, marinas ranged from seven docks to a high of 750 docks.[2] Once again, Ottawa county surpassed the other three counties in numbers of docks with 69 percent of the total.

Marinas were categorized by relative size and by county in Table 5. The majority contained 100 docks or less. The only notable variation in this pattern occurred in Ottawa county. Nearly a tenth of its marinas had more than 251 docks whereas Erie, Lucas and Sandusky counties had far fewer: two, four and zero percent, respectively. This is probably because Ottawa county is the center of Ohio's Lake Erie fishing and boating activity.

As noted previously, the only sources of information regarding numbers of marina ramps and hoists were Mischon, et al. (1979) which was somewhat dated and the NOAA maps which showed only a fraction of the marinas. Therefore, the data presented in Table 4 probably understate the actual numbers of ramps and hoists in existence in the region. Nevertheless, the distribution of ramps and hoists by county followed the pattern of marina distribution. The main deviation appeared in the case of Lucas county which had proportionately fewer launch ramps than expected.

In total, ten marinas were identified which had dry rack storage facilities. All but one were located in Ottawa county. Together, they accounted for a total of 1559 rack storage spaces, up from 826 spaces found

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2 To legally be called a marina in the state of Ohio, a facility must have at least seven docks (ODH, No date).

Table 4. Number of Marinas, Marina Ramps, Hoists, Docks and Public Ramps in the Study Region by County, 1984

County	Marinas	Marina Ramps	Hoists	Docks	Public Ramps
			number (percent)		
Ottawa	137 (64)	90 (75)	52 (51)	13198 (69)	10 (42)[2]
Erie	48 (23)	23 (19)	36 (35)	3817 (20)	2 (9)
Lucas	23 (11)	2 (2)	13 (13)	1862 (10)	10 (43)[3]
Sandusky	5 (2)	5 (4)	1 (1)	129 (1)	1 (5)
Total	213 (100)	120 (100)	102 (100)	19006 (100)[1]	23 (100)

[1]The total represents 204 marinas. Information on number of docks was unavailable for nine marinas.

[2]Two locations in Ottawa County had two ramps.

[3]Three locations in Lucas County had two ramps.

Sources: Mischon, et. al., 1979, County and Health Department Marina Lists, $ODNR_a$, 1977, $ODNR_b$, no date, US-GL, Lake Erie, US-GL, Michigan.

in 1979 (Wenner, 1982). Capacities ranged from 40 to 275 spaces. Representatives of only two of the ten marinas indicated that there were plans to expand their dry rack capacity in the foreseeable future.

In total, 23 public ramps at 18 different sites were identified and located on the NOAA maps within the study region. The distribution of public launch ramps among the four counties is presented in Table 4 which shows that the majority were concentrated in Ottawa and Lucas counties. Each had ten ramps. Only two public ramps were found in Erie County and one in Sandusky county.

Water Depths at the Facilities

Summary data concerning the number of marinas, marina ramps, hoists docks, rack spaces and public launch ramps situated at various depths at low water datum appear in Table 6. The majority of facilities--79 percent of marinas, 82 percent of marina ramps, 72 percent of hoists, 72 percent of docks, 89 percent of rack spaces and 96 percent of public launch ramps--were found to be in one to three feet of water at low water datum. The distribution of marinas by size and by water depth at low water datum is presented in Table 7.

To determine below what point a marina or launch ramp was considered inoperable in this study, a determination had to be made about the size and draft of the average boat that used the Lake. Since it was beyond the scope of this study to survey marinas individually in order to obtain this information, several alternative sources were consulted.

The Army Corps of Engineers, which issues permits for the construction of new marinas, recommends that, for safety, marinas be built to a depth of six feet at low water datum. However, a source from the Corps of En-

Table 5. Number of Marinas in the Study Region by Dock Capacity and by County, 1984.

Number of Docks	County				
	Ottawa	Erie	Lucas	Sandusky	Total
	number of marinas (percent)				
7-50	60 (44)	26 (54)	11 (48)	3 (60)	100 (47)
51-100	35 (25)	8 (17)	7 (31)	1 (20)	51 (24)
101-150	18 (13)	5 (11)	1 (4)	0 (0)	24 (11)
151-200	5 (4)	2 (4)	2 (9)	0 (0)	9 (4)
201-250	2 (1)	3 (6)	1 (4)	0 (0)	6 (3)
251+[1]	12 (9)	1 (2)	1 (4)	0 (0)	14 (7)
Unknown	5 (4)	3 (6)	0 (0)	1 (20)	9 (4)
Total	137 (100)	48 (100)	23 (100)	5 (100)	213 (100)

[1]Seven marinas had between 251 and 400 docks, five fell into the 401-600 dock range and two had between 601 and 750 docks.

Sources: Mischon, et. al., 1979, County and Toledo Department of Health Marina Lists.

Table 6. Number of Marinas, Marina Ramps, Hoists, Docks, Rack Spaces and Public Launch Ramps in the Study Region at Various Water Depths in Feet at Low Water Datum, 1984

Feet at Low Water Datum	Marinas	Marina Ramps	Hoists	Docks	Rack Spaces	Public Ramps
			number (percent)			
1	44 (21)	30 (25)	13 (13)	3050 (16)	0 (0)	5 (22)
2	84 (39)	50 (42)	40 (39)	6140 (32)	605 (39)	11 (48)
3	40 (19)	18 (15)	21 (20)	4506 (24)	776 (50)	6 (26)
4	16 (8)	6 (5)	13 (13)	1315 (7)	178 (11)	0 (0)
5	14 (7)	7 (6)	9 (9)	1709 (9)	0 (0)	1 (4)
6	8 (4)	5 (4)	4 (4)	808 (4)	0 (0)	0 (0)
7	4 (2)	3 (3)	2 (2)	1220 (7)	0 (0)	0 (0)
8	2 (<1)	1 (<1)	0 (0)	258 (1)	0 (0)	0 (0)
9	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	213 (100)	120 (100)	102 (100)	19006 (100)	1559 (100)	23 (100)

SOURCES: Mischon, et. al., 1979, US-GL, Lake Erie, US-GL, Michigan, $ODNR_a$, 1977, $ODNR_b$, no date.

Table 7. Number of Marinas in the Study Region by Number of Docks at Various Water Depths in Feet at Low Water Datum, 1984

Number of Docks	Feet at Low Water Datum									
	1	2	3	4	5	6	7	8	9	Total
	(number of marinas)									
7-50	25	46	15	4	6	4	0	0	0	100
51-100	8	18	11	5	4	2	2	1	0	51
101-150	6	9	3	3	2	1	0	0	0	24
151-200	0	4	3	1	0	0	0	1	0	9
201-250	2	1	2	1	0	0	0	0	0	6
251+	1	4	4	0	2	1	2	0	0	14
Unknown	2	2	2	2	0	0	0	0	1	9
Total	44	84	40	16	14	8	4	2	1	213

Sources: US-GL, Lake Erie, US-GL, Michigan, County and Toledo Health Department Marina Lists, Mischon, et. al., 1979.

gineers estimated that the average power boat using Lake Erie ranges from 28 to 34 feet and has a draft of 30 inches while the average sailboat has a draft of four to four and one-half feet. A source from the Lake Erie Marine Trades Association estimated that the average-sized power and sail boats used in the western basin were 18 feet with drafts of two and three feet respectively. An estimate concerning the ratio of power to sail boats registered for use of Lake Erie was given as seven to one. Taking into account the information provided by these sources, a depth of three feet was chosen as the reference point below which a marina or public ramp would be considered inoperable for the purposes of this study.

Lake Erie water levels generally range between 570 and 572 feet during the month of June. The long-term average June water level (1900-1981) is 571.06 feet and that of a more recent period (1966-1981) is approximately one foot higher; 572.04 feet (USDC-NOAA, no date). Applying the three foot standard, it is clear that even if the June water level dropped to 570.6 feet (two feet above low water datum), all of the facilities in this study would be operable.

However, since 1900, the average June water level on Lake Erie has fallen below 570.6 feet 31 times. If the Lake dropped to between 569.6 and 570.6 feet, as it has 26 times since 1900, boating facilities situated in one foot of water at low datum (21 percent of marinas, 25 percent of marina ramps, 13 percent of hoists, 16 percent of docks and 22 percent of public ramps) would be rendered inoperable according to the parameters set in this study (Table 8).

Since 1900, average June water levels have ranged between 568.6 and 569.6 feet (one foot above low water datum) a total of four times (Table 8). Within this range, another 39 percent of the marinas and 48 percent of

Table 8. Frequency With Which Lake Erie Has Fallen to Various Water Levels During the Fishing Season Measured at Cleveland, Ohio, 1900-1983

Month	<570.6, ≥569.6 Ft	<569.6, ≥568.6 Ft	<568.6 Ft	<570.6 Ft. Total
	frequency (percent) [1]			
May	26 (31)	7 (8)	1 (1)	34 (40)
June	26 (31)	4 (5)	1 (1)	31 (37)
July	21 (25)	6 (7)	1 (1)	28 (33)
August	22 (26)	10 (12)	1 (1)	33 (39)
September	29 (35)	12 (14)	2 (2)	43 (51)
October	42 (50)	15 (18)	1 (1)	58 (69)

[1] n = 84.

SOURCE: USDC-NOAA, No date, Monthly Water Inventory Report for Ohio, 1976-1983.

the public launch ramps, or a total of 60 and 70 percent of the facilities, respectively, would become inoperable. If the level fell below low water datum as in June 1934, an additional 19 percent of the marinas and 26 percent of the public launch ramps in the study region would be unusable. Only 21 percent of marinas and four percent of the public ramps in the region would be operable at this water level.

Throughout this study, average June water levels were used as a reference point. As discussed previously, average June water levels are generally higher than those for the other months of the Lake Erie fishing season. As the fishing season progresses, Lake levels are expected to decline due to natural processes by 0.5 to 1.5 feet so that boating facilities operable in June may become inoperable later in the season.

The data assembled in Table 8 clearly illustrate this point. Average Lake levels tend to drop below 570.6 feet more frequently at the beginning and at the end of the fishing season rather than during the months which coincide with the height of sport fishing activity. Further examination of the historical data reveals that for 32 of the last 84 years, average monthly water levels remained below 570.6 feet for four to six months of the six month Lake Erie fishing season (USDC-NOAA, no date).[3] For this reason, it is assumed in this study that if average water levels are low in June, they will remain low for the whole fishing season.

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3 Years during which average monthly water levels remained low for all or most of the Lake Erie fishing season included 1901-1902, 1910, 1911, 1915, 1918, 1920, 1923-1928, 1931-1942, 1958, 1959, 1962-1966.

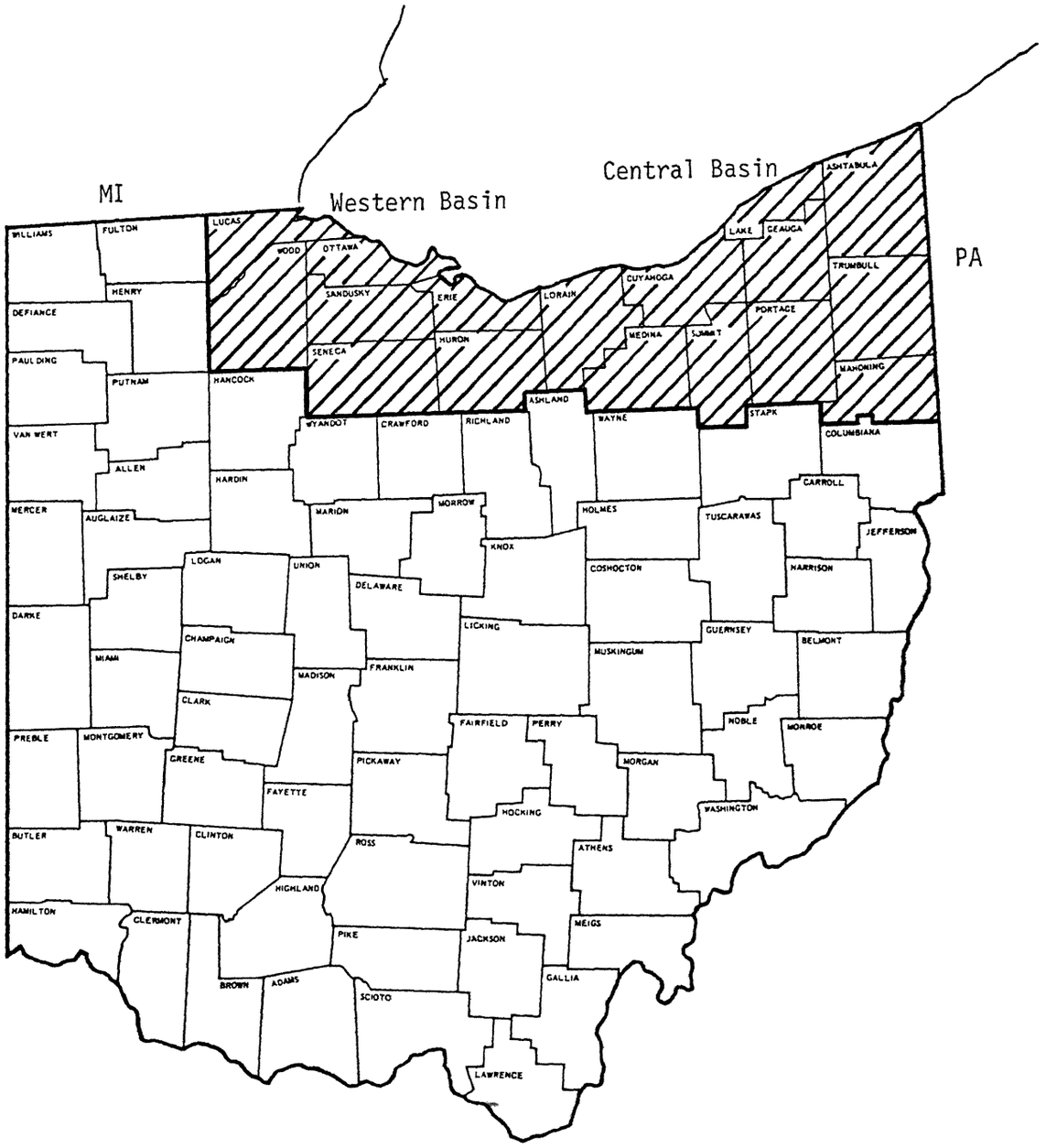
Impacts of Changing Water Levels on Economic Activity Associated With Sport Fishing

A change in any part of the economy leads to changes in its other sectors. Thus, to measure the impact of a certain economic activity on the whole economy--sport fishing in this study--it is necessary to trace out both the direct and indirect effects to all other economic sectors. To accomplish this, it is necessary to know how the various economic sectors relate to each other. One method which does this is input-output (I/O) analysis.

In I/O analysis, all economic activity is categorized into either endogenous or exogenous sectors. Firms within a given endogenous sector produce a set of similar goods and services for sale to other endogenous sectors or to exogenous (final demand) sectors, such as export and household consumption. The flow table of an I/O model describes the demand and supply relationships of an economy in equilibrium by showing final demand for goods and services and the interindustry transactions required to satisfy the demand. Coefficients which measure the direct and indirect effects of changes in output in each sector resulting from a $1 change in final demand for a given processing sector are derived from the flow tables. I/O models also permit calculation of the impact on regional output, income and employment caused by changes in final demand for a given sector.

In this study a 43-sector open, static input-output model was used to assess the impact on the regional economy of declines in sport fishing brought about by declining water levels surrounding the marinas and public ramps of the western basin (Apraku, 1983; Hushak, Morse and Apraku, 1984). The study region covered by the model is shown in Figure 4 and includes not

Figure 4. Study Region Covered by the I/O Model.



only the four western basin counties but 13 others in northern Ohio that are directly affected by economic activities relating to Lake Erie. The 1972 U.S. National I/O model updated to 1978 prices was used to derive 40 sectors of the regional model. Data for the remaining three sectors were obtained through primary surveys (Apraku, 1983; Hushak, Morse and Apraku, 1984; Winslow, 1982). The highly disaggregated 365-sector national model was adapted to reflect the size and structure of the region's economy.

This study focused on the interrelationships between seven endogenous sectors and the final demand sector, sport fishing. All 43 sectors of the I/O model and their output multipliers are shown in the Appendix (Apraku, 1983; Hushak, Morse and Apraku, 1984). The seven endogenous sectors are marina/boat sales, boat/ship building and repair, charter fishing, eating/drinking establishments, retail, hotel/lodging and miscellaneous services. Sport fishing is an exogenous sector consisting of charter and private boat anglers which generates its economic impact through the direct purchase of output from the seven endogenous sectors.

The total economic impact on the 17-county region of expenditures made by charter and private boat anglers in 1981 is summarized in Table 9. Column 1 shows that overall, sport anglers spent nearly $50 million in the region during that year. Over one-half went for purchases from the marina/boat sales sector which encompasses boats, boating supplies, bait, tackle and dockage. Expenditures in the retail and eating/drinking sectors amounted to 18 and 12 percent of the total respectively while proportionately less went for purchases from the remaining sectors.

Columns 2, 3 and 4 of Table 9 show the total impact of the direct spending by sport anglers in each of the six sectors on output, income and employment in the region. In total, the nearly $50 million spent in 1981

Table 9. Total Economic Impact of Lake Erie Sport Fishing on the Northern Ohio Economy, 1981

Sectors	Direct Spending ($ mil.)	(%)	Output ($ mil.)	(%)	Income ($ mil.)	(%)	Employment (man-yrs.)	(%)
Marina/Boat Sales	25.72	(51.6)	49.38	(54.5)	20.32	(63.9)	1622.93	(58.1)
Boat/Ship Building & Repair	2.3	(4.6)	4.67	(5.2)	1.89	(5.9)	71.30	(2.6)
Charter Fishing	4.06	(8.1)	9.09	(10.0)	3.09	(9.7)	236.70	(8.5)
Eating/Drinking	6.07	(12.2)	10.74	(11.9)	1.03	(3.2)	178.46	(6.4)
Retail	8.88	(17.8)	11.99	(13.2)	4.62	(14.5)	553.22	(19.8)
Hotel/Lodging	2.47	(5.0)	4.12	(4.5)	.79	(2.3)	116.09	(4.2)
Misc Services	.32	(0.6)	.56	(0.6)	.07	(0.2)	12.9	(0.5)
Total	49.82	(100)	90.55	(100)	31.81	(100)	2791.6	(100)

Source: Calculated from Tables 12, 14 and 15, Hushak, Morse and Apraku, 1984.

generated almost $91 million of output, $32 million of income and 2792 man-years of employment in the region. These figures were obtained by multiplying Column 1 (direct spending) by the appropriate output multipliers and total income and total employment effects listed in Table 10.

Impact of Declining Water Levels

There are two assumptions underlying the estimates made under the three scenerios defined below. First, all boating facilities are assumed to be operating at full capacity so there can be no site substitution. If a facility is rendered unusable due to declining water levels, sport anglers are unable to move to alternative facilities. Therefore, a drop in the pool of boating facilities leads to a proportionate decline in sport fishing expenditures. Second, as discussed previously marinas and public ramps judged to be inoperable in June will remain so for the whole fishing season. Lake Erie generally reaches its peak water level in June and low water levels experienced in June would become still lower if the normal seasonal cycle occurred.

Scenario 1. Under Scenario 1, June water levels decline to between 569.6 and 570.6 feet. Consequently, 21 percent of marinas and 22 percent of public ramps are rendered inoperable. Direct spending by sport anglers is assumed to drop by 21 percent from the base level to $39.36 million which in turn generates $71.53 million of output, $25.13 million of income and 2205.36 man-years of employment in the region (Table 11). The region loses $10.46 million of direct spending, $19.02 million of output, $6.68 million of income, and 586.24 man-years of employment (second section of Table 11).

Table 10. Output Multipliers, Total Income Effects and Total Employment Effects for Regional Sectors, 1978

Sectors	Output Multiplier	Total Income Effect	Total Employment Effect
	(per $1 of final demand)		(man-years/$ million of final demand)
Marina/Boat Sales	1.92	.79	63.1
Boat/Ship Repair and Building	2.03	.82	31.0
Charter Fishing	2.24	.76	58.3
Eating/Drinking	1.77	.17	29.4
Retail	1.35	.52	62.3
Hotel/Lodging	1.67	.32	47.0
Misc Services	1.74	.21	40.2

Source: Tables 5, 6 and 7. Hushak, Morse and Apraku, 1984.

Table 11. Effect of Declining Lake Erie Water Levels on Direct Spending by Sport Anglers and the Impact on Regional Output, Income and Employment--Three Scenerios, 1981

	Direct Spending	Output	Income	Employment
		($ million)		(man-years)
Level[1]				
Base	49.82	90.55	31.81	2791.60
Scenerio 1	39.36	71.53	25.13	2205.36
Scenerio 2	19.43	35.31	12.41	1088.72
Scenerio 3	9.47	17.20	6.04	530.40
Incremental Loss[2]				
Base to Scenerio 1	10.46	19.02	6.68	586.24
Scenerio 1 to Scenerio 2	19.93	36.22	12.72	1116.64
Scenerio 2 to Scenerio 3	9.96	18.11	6.37	558.32
Total Loss[3]				
Base to Scenerio 1	10.46	19.02	6.68	586.24
Base to Scenerio 2	30.39	55.24	19.40	1702.88
Base to Scenerio 3	40.35	73.35	25.77	2261.20

[1]Water levels and proportions of operational facilities under the base and the three alternative scenerios:

	Water Level	% of Operational Facilities
Base	571 feet or above	100
Scenerio 1	570.6 to 569.6 feet	79
Scenerio 2	569.6 to 568.6 feet	39
Scenerio 3	below 568.6 feet	19

[2]These figures represent the incrmental losses of direct spending, output, income and employment sustained by the study region if Lake Erie water levels decline to the ranges of the three alternative scenerios.

[3]These figures represent the total loss of direct spending, output, income and employment sustained by the study region if Lake Erie water levels decline from the base level to the ranges of the three alternative scenerios.

Source: Calculated from Table 9.

Scenario 2. In Scenerio 2, June water levels drop to between 568.6 and 569.6 feet leaving 60 percent of marinas and 70 percent of public ramps in water too shallow for boating. Taking the weighted average of the two, 61 percent of boating facilities are inoperable resulting in a 61 percent decrease in direct spending by sport anglers and a proportional decrease in regional output, income and employment. The results for Scenario 2 are summarized in Table 11. They show that if Lake levels decline from the Scenerio 1 to the Scenerio 2 range, the region loses another $19.93 million of direct spending, $36.22 million of output, $12.72 million of income and 1116.64 man-years of employment. Total losses under Scenerio 2 are $30.39 million of direct spending, $55.24 million of output, $19.40 million of income and 1702.88 man-years of employment (third section of Table 11).

Scenerio 3. June water levels under Scenerio 3 drop below low water datum (568.6 feet) leaving 79 percent of marinas and 96 percent of public ramps inaccessible to boaters. A weighted average of these percentages shows 81 percent of the boating facilities to be inoperable at this water level. In this case, sport anglers reduce their purchases to $9.47 million which generate $17.20 million of output, $6.04 million of income and 530.40 man-years of employment within the region (Table 11). The incremental loss to the region of a decline in water levels from the Scenerio 2 to Scenario 3 range amounts to $9.96 million of direct spending, $18.11 million of output, $6.37 million of income, and 558.32 man-years of employment. Total losses under Scenerio 3 are $40.35 million of direct spending, $73.35 million of output, $25.77 million of income and 2261.2 man-years of employment.

Estimates of Expected Annual Loss of Direct Spending, Output, Income and Employment

Probabilities of the three scenerios occurring in the future are estimated from historic water level data. Since 1900, average June water levels have dropped to the range specified in Scenerio 1 (570.6 Ft, _ 569.6 Ft) 26 times (Table 8). Therefore, the probability of Scenerio 1 occurring in any future year in 26/84 or 31 percent. Similarly, over the last 84 years, average June water levels have fallen to the Scenerio 2 range (569.6 Ft, _ 568.6 Ft) four times (five percent) and to the Scenerio 3 range (568.6 feet) once (approximately one percent).

Probability estimates and the economic losses associated with each scenerio are used to calculate the expected annual losses of direct spending, output, income and employment to the region. The equation used to calculate the expected losses is:

$$(1)\quad EL_i = .31\ (\text{Base - Scenario 1 loss})_i + .05\ (\text{Base - Scenerio 2 loss})_i + .01\ (\text{Base - Scenerio 3 loss})_i$$

where i = direct spending, output, income or employment.

Column one of the third section of Table 11 summarizes total losses of direct spending to the study region if water levels drop to the depths specified under the three alternative scenerios. Under Scenerio 1, the region loses $10.46 million of direct spending and if water levels drop to the Scenerio 2 range another $19.93 million or a total of $30.39 million of direct spending is lost. Similarly, total direct spending losses of $40.35 million occur at the Scenerio 3 range.

Using equation (1), the total expected annual direct spending loss is estimated to be $5.17 million or approximately ten percent of the total spent annually on Lake Erie sport fishing in northern Ohio. The expected annual output, income and employment losses are calculated in the same manner. Those results yield estimated annual losses to the region of $9.39 million of output, $3.30 million of income and 289.47 man-years of employment. These losses represent approximately ten percent of the respective estimates of total annual output, income and employment generated annually within the region by sport fishing activity on Lake Erie.

Impacts of Changing Water Levels on Economic Value of Sport Fishing

Since September 1980, three studies have been conducted to ascertain how private boat anglers value various components of Ohio's Lake Erie fishery (Dutta, 1984; Hushak, Winslow and Dutta, 1984; Winslow, 1982). The study results were used in this report to estimate the impact of declining Lake water levels on the value attributed to the Lake Erie fishing experience by sport anglers.

The three components of the Lake Erie fishery studies were: (1) the western basin, May through August 15, 1981, called the walleye sample, (2) the western basin, August 15 through November, 1981, called the yellow perch sample, and (3) the central basin, 1982. In each study, private boat anglers were approached at a launch or dock site and asked if they would respond to a questionnaire concerning their Lake Erie fishing experience (Shore anglers and those who hired charter services were excluded from the studies). At the close of the season, questionnaires were sent to those who had expressed their willingness to participate in the studies. In-

formation was gathered about income, fishing group size, number of trips, length of trips, hours spent on fishing and recreation, distance travelled and harvest rates for three fish species (for more information consult Hushak, Winslow and Dutta, 1984). A general discussion of the model and the methodology applied in the three studies follows.

The recreation or travel cost demand methodology was used to estimate the value placed on Lake Erie sport fishing by private sport anglers. Recreation costs can be divided into two categories: travel costs and on-site costs. Travel costs include the costs of human time involved in travelling to and from a recreational site as well as money costs for gas and oil, vehicle wear and tear, food and other expenditures made in transit. Travel costs are included in the valuation of a recreational experience because demand for a trip is a function of its price which is equivalent to the quantity of resources a recreationist is willing to forego in exchange for a trip. Thus, travel costs serve as a proxy for estimating the price of a trip. On-site costs are composed of the human time cost of participation in a recreational experience and costs of things like recreational equipment, food, lodging and entry fees.

There is little agreement about how to value the human time component of travel costs. Some researchers advocate that leisure time be valued at the full working wage rate if a recreationist gives up the opportunity to work in order to travel and engage in recreational activity. When the option to work is absent, time spent on recreation may be valued according to the value of the next best leisure activity. If the recreationist has no possibility to work more hours or to engage in any other leisure

pursuit, time spent on travel and at the site should be valued at zero. In the studies cited in this report, time costs were valued at zero, 25 and 50 percent of the wage rate of sport anglers.

Total willingness to pay for sport fishing is derived from demand curve estimates and has three components: (1) costs of travel to and from the site, (2) on-site costs and (3) net consumer surplus (see Figure 5). In the three studies, only travel costs were used to determine the price of a fishing trip for estimation of the demand curve. The mean value of on-site costs (a constant) was then added to this price to locate the demand curve correctly.

Consumer surplus is defined as the difference between the price a consumer actually pays for a given amount of a good and the price that the consumer would have been willing to pay rather than do without it. In the three studies, net consumer surplus--the triangular area above the price (P) and below the demand curve in Figure 5--represents the value of Lake Erie fishing to private-boat sport anglers over and above the economic costs of money and time spent on travel and at the site. Since net consumer surplus is valued over and above economic costs, it represents an estimate of the annual public investment justified to keep docks and launch facilities in operation for sport anglers. For a more detailed account of how the demand curve was derived and how estimates of total willingness to pay were calculated in the three studies, see Dutta, 1984; Hushak, Winslow and Dutta, 1984; and Winslow, 1982.

Table 12 summarizes the estimates of travel and on-site costs, net consumer surplus and total willingness to pay for the three study samples with human time valued at zero, 25 and 50 percent of private-boat anglers' wage rates. Estimates are highest for the walleye sample since nearly 68

Figure 5. On-Site Costs, Travel Costs, and Net Consumer Surplus

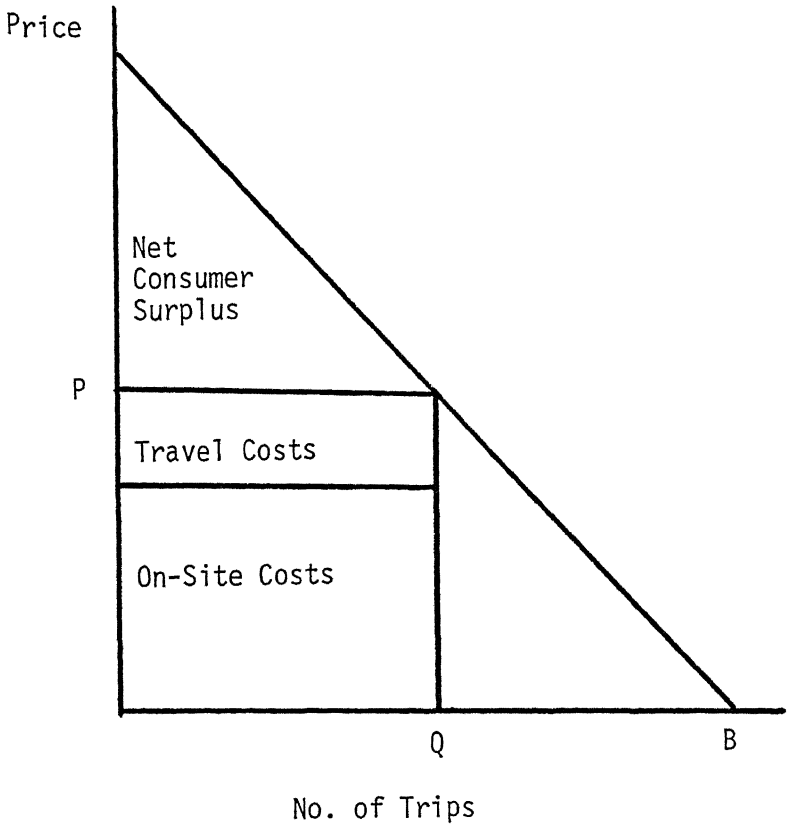


Table 12. Aggregate Estimates of Travel Costs, On-Site Costs, Net Consumer Surplus and Willingness to Pay[1]

	Human Time as a Percent of Wage Rate		
	0	25	50
		($ million)	
Travel Costs			
Western basin-walleye	8.89	12.58	20.97
Western basin-yellow perch	1.87	2.74	3.69
Central basin	1.19	2.12	3.05
Total	11.95	17.44	27.71
On-Site Costs			
Western basin-walleye	40.50	69.16	97.83
Western basin-yellow perch	6.60	11.52	16.45
Central basin	5.28	15.13	24.97
Total	52.38	95.81	139.25
Net Consumer Surplus			
Western basin-walleye	19.77	22.90	36.11
Western basin-yellow perch	4.67	5.45	6.99
Central basin	.94	1.60	2.38
Total	25.38	29.95	45.48
Total Willingness to Pay			
Western basin-walleye	69.16	104.64	154.91
Western basin-yellow perch	13.13	19.71	27.12
Central basin	7.41	18.85	30.40
Total	89.70	143.20	212.43

[1]Dates of these studies were 1981 and 1982.

Source: Compiled from Tables 2, 3, and 4 of Hushak, Winslow and Dutta, 1984.

thousand sport anglers (in aggregate) fished Lake Erie during that fishing period compared with only about 31 thousand and 21 thousand during the yellow perch season and in the central basin, respectively (Hushak, Winslow and Dutta, 1984). With time valued at zero, net consumer surplus is $25.38 million and total willingness to pay is $89.7 million. When the value of time is set at 25 percent of the wage rate, net consumer surplus amounts to nearly $30 million and total willingness to pay is $143.2 million. Net consumer surplus is $45.48 million and total willingness to pay $212.43 million, when time is valued at 50 percent of the wage rate.

Impact of Declining Water Levels

Table 13 summarizes the effects of declining Lake Erie water levels on net consumer surplus under the three alternative scenerios. Net consumer surplus is used as the basis of the calculations because of the investment implications of this value.

Scenerio 1. Under Scenerio 1, only 79 percent of the boating facilities are operational. It is assumed that use of Lake Erie drops by 21 percent and that net consumer surplus diminishes proportionately. Thus, if Lake Erie water levels fell into the Scenerio 1 range, the loss of net consumer surplus would amount to $5.33 million if time was valued at zero, $6.29 million if it was valued at 25 percent of the wage rate or $9.55 million if the value of time was set at one-half of the wage rate.

Scenerio 2. Under Scenerio 2, only 39 percent of the marinas and launch ramps found within the study region are usable. This would mean total net consumer surplus losses of $15.48 million, $18.27 million and $27.74 million respectively if time was valued at zero, 25 and 50 percent of the wage rate.

Table 13. Effect of Declining Lake Erie Water Levels on Net Consumer Surplus--Three Scenerios, 1981

	Consumer Surplus		
	Human Time as Percent of Wage Rate		
	0	25	50
	($ million)		
Level[1]			
Base	25.38	29.95	45.48
Scenerio 1	20.05	23.66	35.93
Scenerio 2	9.90	11.68	17.74
Scenerio 3	4.82	5.69	8.64
Incremental Loss[2]			
Base to Scenerio 1	5.33	6.29	9.55
Scenerio 1 to Scenerio 2	10.15	11.98	18.19
Scenerio 2 to Scenerio 3	5.08	5.99	9.10
Total Loss[2]			
Base to Scenerio 1	5.33	6.29	9.55
Base to Scenerio 2	15.48	18.27	27.74
Base to Scenerio 3	20.56	24.26	36.84

[1]Water levels and proportions of operational facilities under the base and the three alternative scenerios:

	Water Level	Percent of Operational Facilities
Base	571 feet or above	100
Scenerio 1	570.6 to 569.6 feet	79
Scenerio 2	569.6 to 568.6 feet	39
Scenerio 3	below 568.6 feet	19

[2]These figures represent the incremental losses of net consumer surplus sustained by sport anglers if Lake Erie water levels decline to the ranges of the three alternative scenerios.

[3]These figures represent the total loss of net consumer surplus sustained by sport anglers if Lake Erie water levels decline from the base level to the ranges of the three alternative scenerios.

Source: Calculated from Table 12.

Scenerio 3. If Lake Erie dropped below 568.6 feet as under Scenerio 3, net consumer surplus losses would total $20.56 million, $24.26 million and $36.84 million if the value of time were set at zero, 25 and 50 percent of the wage rate, respectively.

Estimates of Expected Annual Loss of Net Consumer Surplus

Estimates of expected annual loss of net consumer surplus were calculated in the same manner as for direct spending, output, income and employment using equation (1). Rows 8, 9 and 10 of Table 13 show the total losses of net consumer surplus under the three alternative scenerios. If time was valued at zero, the expected annual net consumer surplus loss would be $2.63 million, or approximately ten percent of total net consumer surplus when all boating facilities are operational. With time valued at 25 and 50 percent of the wage rate, total annual expected net consumer surplus losses would amount to $3.11 million and $4.73 million, respectively.

Conclusions and Implications

Summary

In total, 213 marinas and 23 public ramps were identified and located on maps of the four counties bordering Lake Erie's western basin. Marinas have increased by nearly 25 percent since 1979. Ottawa county has the largest share of marinas, marina ramps, hoists, docks and rack spaces whereas public ramps are concentrated in both Lucas and Ottawa counties. The western basin region is dominated by small marinas with 71 percent having 100 docks or less. Most marinas and public ramps are located in from one to three feet of water at low water datum.

In 1981 sport anglers spent nearly $50 million in the region which stimulated almost $91 million of output, $32 million of income and 2792 man-years of employment. The average June Lake Erie water level for 1900-1981 is 571 feet at which all facilities are operable under the assumptions of this study. If Lake Erie water levels declined to between 569.6 to 570.6 feet, approximately 21 percent of the boating facilities in the region would be inoperable resulting in a 21 percent drop in direct spending by sport anglers with a proportional decline in the region's output, income and employment. Should the Lake drop to between 568.6 and 569.6 feet in June as it has four times since the year 1900, only 39 percent of the boating facilities would remain open accompanied by a 61 percent decrease in direct spending by sport anglers and a correspondingly negative impact on the region's economy. Finally, should June Lake Erie levels fall below 568.6 feet as they have once since 1900, the economy would lose $40.35 million of sport anglers' direct purchases and $73.35 million of output, $25.77 of income and 2261.2 man-years of employment because only 19 percent of the boating facilities would then be in operation. The annual expected loss to the region amounts to $7.9 million of output, $2.8 million of income and 243 man-years of employment, or about 9 percent of sport fishing activity in 1981.

From previous studies, an economic valuation of the Lake Erie fishing experience to sport anglers revealed that their total willingness to pay for the sport fishing activity was approximately $90 million, $143 million and $212 million respectively when time was valued at zero, 25 and 50 percent of private-boat anglers' wage rates. Seventy to eighty percent of

those willingness-to-pay estimates were composed of travel and on-site costs. The remainder represented the net consumer surplus, i.e., the value placed on fishing over and above economic costs.

If time was valued at zero, the loss of net consumer surplus under the three alternative scenerios would be approximately $5 million, $15.5 million and $20.6 million, respectively. With time valued at 25 percent of the wage rate, losses of net consumer surplus would be $6 million under Scenerio 1, $18 million under Scenerio 2 and $24.3 million under Scenerio 3. Similarly, with the value of time set at one-half the wage rate, net consumer surplus losses under Scenerio 1 would be about $9 million, Scenerio 2 losses would be approximately $28 million and Scenerio 3 losses would approach $37 million. Annualized expected net consumer surplus losses would amount to $2.6 million, $3.1 million and $4.7 under the three respective time valuations.

Study Limitations

Several limitations to this study arose from the data sources. The maps showing water depths of western basin marinas, channels and harbors were somewhat dated. Several knowledgeable persons consulted during the course of this project remarked that significant channel and marina dredging had occurred in the western basin over the last year or two. Consequently, the percent of marinas and public ramps shown to be inoperable under the various scenerios may be overestimated as of 1984.

Data concerning the water depths found at marinas and public ramps of the central basin were not collected. It was assumed that the proportions of central basin facilities at various water depths were similar to those of the western basin. Because the majority of boating facilities and most

of the economic activity associated with sport fishing occur in the western basin region (Table 1), the impact of this assumption on the results is minimal.

Since information concerning the usage rates of public ramps and marinas was unavailable, all facilities were weighted equally in this study. Because they were assumed to be operating at capacity, no allowance was made for site substitution. By not taking this into account, the impact of declining sport fishing activity on the regional economy was probably overestimated.

Estimates of economic losses to the region were made under the assumption that a drop in the pool of boating facilities leads to proportionate declines in sport fishing-related expenditures. Although it is possible that certain expenditures may be unaffected by declining Lake Erie water levels, at least in the short-run, such estimates are not readily available. To the extent that this occurs, however, estimates of economic losses to the region under the three scenerios would be excessive.

The decision to use three feet as the reference point for determining the viability of boating operations was not an arbitrary one. However, short of surveying them, there was no way to know which marinas handled various sized boats nor what percent of boats using Lake Erie actually fell into the "average" category. The impact on the regional economy of declining Lake Erie water levels was calculated under the assumption that marinas and public ramps inoperable in June would remain so for the reset of the fishing season. However, facilities viable in June may not be viable later in the season especially when June water levels are below 571 feet.

Implications

It is apparent from the data gathered in this study that the majority of marinas and public launch ramps are not maintained at the six foot depth recommended by the U.S. Army Corps of Engineers. Historic water level data suggest a 31 percent probability that water levels in a future year will drop and render approximately 20 percent of these facilities unusable. The probability of water levels declining to a point where more than 20 percent are affected is only five percent. Thus, Army Corps of Engineer recommendations seem excessive for the majority of boating operations in this study unless they handle sailboats or larger-than-average watercraft. However, private marina owners have the incentive to keep their facilities operational. The depth at which they maintain their marinas depends in part on the degree of risk they wish to assume based on probability estimates of water depths declining to threatening levels in the future.

The $3.3 million estimate of expected annual income loss to the region serves as a benchmark for public investment at the county, regional or state level for clearing and/or maintaining navigable channels and public launch ramps. Since short-run income losses to the region occur under the three alternative scenerios discussed in this report, there is some justification for public expenditures of up to $3.3 million annually to insure that sport anglers have access to the Lake under low water conditions. The estimated annual net consumer surplus loss ($2.6 million) to the region due to declining Lake Erie water levels also may be used as a gauge for such public investments to satisfy the demand of sport anglers for fishing opportunities on Lake Erie. It would be appropriate, for

example, to use fishing license revenues for channel dredging to insure that sport fishing is not reduced and the net consumer surplus is acquired by sport anglers.

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Appendix

Ranked Output Multipliers for Regional Endogenous Sectors, 1978

Endogenous Sectors	Output Multipliers
Motor vehicle equipment	2.37
Charter fishing	2.24
Livestock	2.13
Water transportation	2.12
Food and kindred products	2.06
Textiles	2.03
Boat-ship building and repair	2.03
Heating, plumbing, fabricated metals	2.01
Other manufacturing	1.99
Primary nonferrous metals	1.96
Finance and Insurance	1.96
Furniture and fixtures	1.94
Auto repair services	1.93
Marina and boat sales	1.92
Electric and electronic equipment	1.89
Rubber and leather	1.87
Chemicals and allied products	1.85
Other fabricated products	1.83
High technology machinery	1.81
Miscellaneous machinery	1.81
Mineral extraction	1.79
Recreation and amusement	1.78
Paper and allied products	1.77
Eating and drinking establishments	1.77
Stone, clay and glass products	1.76
Primary iron and steel mfg.	1.74
Miscellaneous services	1.74
Construction	1.72
Hotel and lodging	1.67
Non-water transportation	1.67
Commercial fishing	1.67
Crops	1.64
Electricity, gas and sanitary	1.63
Other mining	1.62
Printing and publishing	1.62
Wood and lumber	1.50
Education services	1.44
Health services	1.42
Communication	1.40
Real estate	1.40
Wholesale	1.37
Retail	1.35
Forestry products	1.33

Source: Apraku, 1983.